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SYNCHRONOUS-FLOW GENERATOR

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16. Abstract

A synchronous flow generator that is being developed in Sweden is described. The results obtained from an investigation into direct frequency reversal with the aid of semiconducters have been used as a basis for designing a synchronous-flow generator. Its uses are foreseen as reserve power plants for hospitals, power supplies on large ships, etc.; large generators of this type are not yet in operation, but their development should take place in the near future.

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Chalmers Technical University
Institute for the Study of
Electrical Machinery
Department Manager: Olle Ljungström
STU

January 16, 1974

The Wind-Power Generator

Referring to our telephone conversation of today, I am sending you a short presentation of the synchronous flow generator which has been developed at the Institute (see pp. 6-7 of enclosed publication).

In principle, the generator is used within a very large effective range; however, I would like to point out that we have not done any studies regarding its usefulness in comparison with other solutions. One can, of course, use a normal synchronous or asynchronous generator as a wind-power generator; the resulting frequency is then converted into 50 Hz, either with a dc converter or with direct change of frequency. In conjunction with this, I would like to mention that we are now in the process of developing a frequency control of an as yet untested type, which could possibly be utilized in connection with wind-power generators.

Since we at the Institute have been most interested in the study of thyristor technology in conjunction with electrical machinery, I would be very happy to present our project at the time of your visit.

Very truly yours,

/s/

Prof. Svante von Zweygbergk

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SYNCHRONOUS-FLOW GENERATOR

S.v. Zweygbergk

The synchronous machine is the normal rotating electrical machine used to produce electrical energy on a large scale; however, it also has other uses: A well known example is as the movement in an electric clock. Here, an essential characteristic is used with this type of machine -- its rpm is tied to the voltage frequency, whether it is used as a generator or a motor. This characteristic has advantages and disadvantages. It is used most effectively in the synchronized watch. The average frequency within the network is very exact, and the result is a simple and inexpensive watch, which keeps good time provided it is properly charged. /6*

Disadvantages of the Ordinary Synchronous Machine

We perceive, however, that the connection of rpm with the network is an obvious disadvantage where generators are concerned. For example, we can mention that today synchronous generators are produced with a rated output on the order of 1 GVA (1000 MVA). Quick load changes in the generator produce major stress on the automatic control system if the performance of the rpm-differential fails as the result of disconnection of the generator unit. The synchronous machine is normally built with a three-phase alternating current in the stator and direct current in the rotor (Fig. 1).

The three-phase currents produce a magnetic flow B_s, which rotates with revolution N_s synchronized with the network frequency. The rotor's field winding is fed with direct current and generates a flow B_f. In order to keep a constant moment, the two propagating waves B_s and B_f must have zero velocity with respect to each other, which means, as was pointed out earlier, that the revolution n_r of the

*Numbers in the margin indicate pagination in the foreign text.

rotor must be the same as n_s.

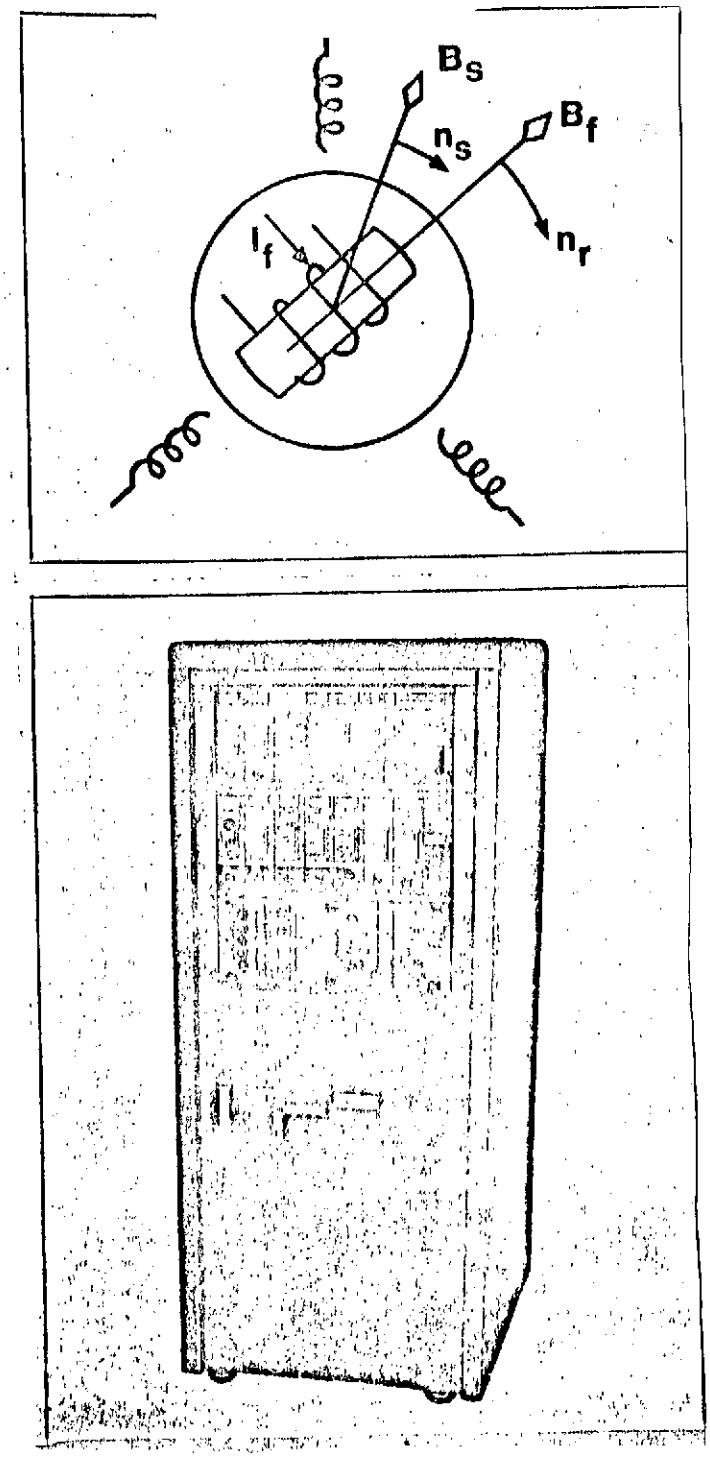

Fig. 1. Principle of construction of the synchronous machine.

Feeding Alternating Current into the Rotor

The concept of a rotor with polyphase winding which is being fed polyphase alternating current of suitable frequency is close to realization. The rotor field will then rotate relative to the rotor. Then, if the frequency of the rotor is governed through a reconnecting system so that the stator wave and rotor wave have zero velocity with respect to each other, the condition for producing a constant moment with varied rotor rpm is fulfilled.

Progress within the sphere of electronics is presently very rapid, and production of available components makes it possible to construct technically sophisticated equipment and to have economical regulation of large amounts of power. The equipment becomes

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completely static with small overhead and slight risk of stoppage.

In 1963, within the scope of a licentiate project at the Institute for the Study of Electrical Machinery, an investigation into direct frequency reversal with the aid of durable semi-conductors (thyristors) began. The results obtained have been used as a basis for designing the operating equipment of a synchronous-flow generator. It is based on the principles given earlier, with alternate current being fed from direct frequency control to the rotor on a synchronous machine. The rotor winding is two-phase, so that the simplest possible control can be obtained. See the simplified diagram in Fig. 2. The work was begun in 1966 with a grant from STFR.

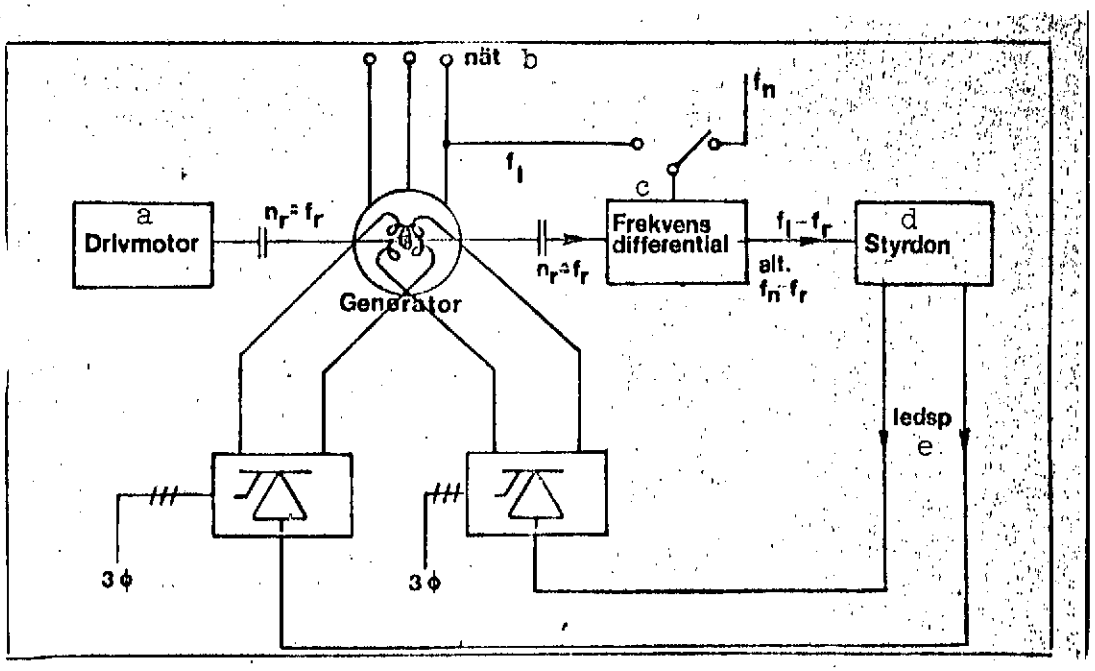


Fig. 2. Block diagram for operating equipment.

Key: a. Drive motor
b. Network
c. Frequency differential
d. Control drive
e. Guide screw

Advantages of the System

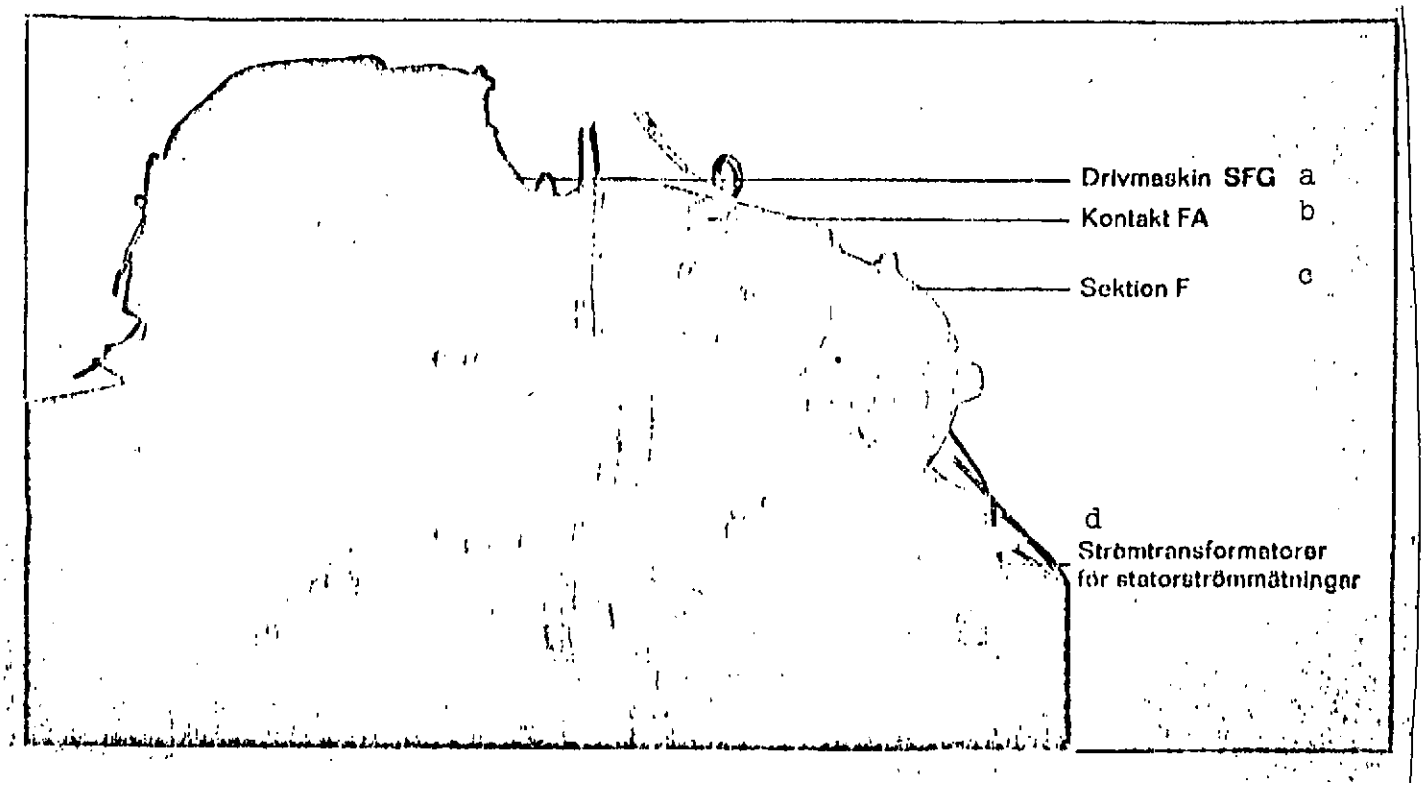
A generator with this type of regulating equipment cannot fail in the ordinary sense, although a quick load change could naturally cause problems. With careful dimensioning, a synchronous-flow generator becomes far superior to the conventional synchronous generator as far as stability is concerned. The generator's voltage frequency can be directed very simply from an external normal frequency, independent of the motor's rpm; this is an essential advantage when the generator is supporting a load by itself, such as a reserve power plant for a hospital, etc.

Generators on Ships

Another topical and interesting use of a synchronous-flow generator is as a reserve power supply on large ships. Here, one is interested in using the main motor to its fullest capacity for the production of extra power; therefore, a synchronous-flow generator would be very attractive. The Institute would be very interested in working with the shipbuilding industry in further development of this area.

Large Generators

The continual extension of large power systems brings about additional problems in stability. These problems can be reduced considerably by the use of synchronous-flow generators. A synchronous-flow generator constitutes an alternative to the refined relay technique which demands certainty of the security of operation for a large power system. As far as we know, no large generators of this type are in operation, but it must be pointed out that due to the advantages they offer (in combination with development of semiconductors in the power field), such construction is not too far away.



Plan of synchronous-flow generator.

Key: a. Synchronous-flow generator drive
b. FA contact
c. F section
d. Current transformer for stator current feed